**Would modern Safety have saved Senna?**

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Abstract

Ayrton Senna had a major accident in the San Marino Grand Prix in 1994 that cost him his life. Taking a look at modern motorsport safety technology, it shows that it is possible for Senna to have survived that accident if it occurred today. Several factors led to this hypothesis. The track design criteria takes into consideration the usage of chicanes, and proper gravel trap areas around a race circuit. Helmet design, including the visor, had changed drastically since 1994. If the improvements took place in Senna’s time his head would have sustained incredibly less damage. Had Senna’s car design included a monocoque and safety cell, the suspension pieces and tire that entered his cockpit could have been kept out. These factors together can be led to prove that Senna could have survived his accident if it occurred in 2011.

Background

While taking a look at modern safety techniques in motorsport compared to those of the past, it seems many accidents could in the past few decades could have been prevented. If we step back and look at how much racing accidents affected safety procedures, we would see clearly that nothing would have happened if these men did not lose their lives. Generally, when something occurs within life, we react to that occurrence and fix it. The same can be said for motorsport. Without the deadly string of accidents in the 1970’s in Formula One, safety would still be decades behind. The same can be said in NASCAR; when Dale Earnhardt lost his life, their safety procedures changed drastically. They even implemented ideas from competing series, such as the Indycar Series, who first did research on the Steel and Foam Energy Recovery (SAFER) barriers. These barriers absorb energy and disperse it over a greater area than if a car hit a concrete wall. This led to advancement in car technology as well. This advancement does, however, lead to certain questions about what would happen if the accidents of the past occurred today. For instance, if Niki Lauda crashed in a modern Formula One car, he could have not been burnt even the slightest bit because of the modern safety wear. At the University of Lausitz we estimate that almost all the accidents of the past that were deadly, could have been prevented. Below, I address a famous accident that could be prevented if today’s modern safety measures were in place.

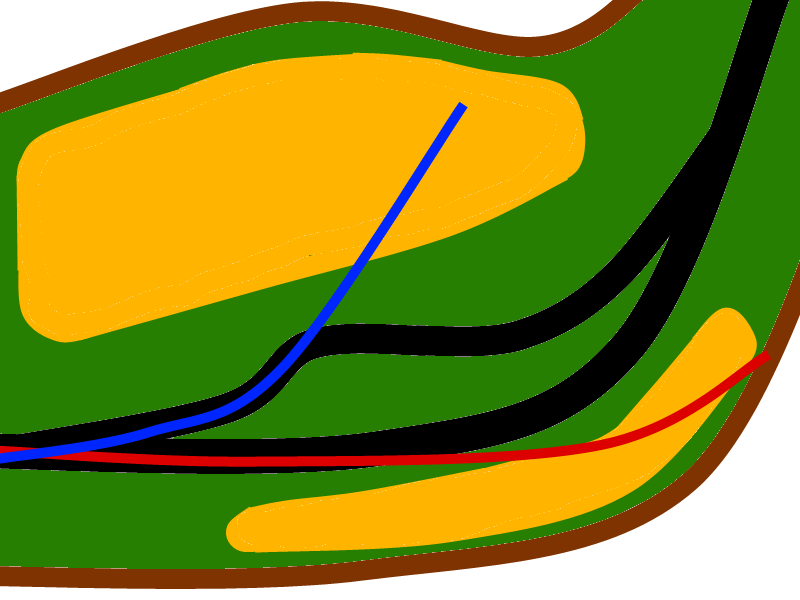
The Accident

One particular incident that changed the scene of motorsport forever was Ayrton Senna’s fatal crash in the San Marino Grand Prix in 1994. He crashed going approximately 220 kph at a slight angle into a solid concrete wall. Before the crash, Senna’s car bounced off the race track with its underside. Sparks flew up, which was not unusual for the start of a race. This, however, was believed to have caused something to break. Senna shortly after lost control. After striking the wall and skidding to a halt, Senna did not try to get out of the car. Once the medical team arrived they knew it was a bad scene. Blood lay inside the car, and his helmet was pierced straight though to his head. The doctors and the rest of the world knew that Senna had passed away. But what caused this? If it happened today, could this have been prevented?

Track Layout

The layout of *Autodromo Enzo e Dino Ferrari*, known as Imola from here on out, was for high speeds. Like many old-style race tracks, they were designed without safety in mind. Imola in particular had many high speed curves that were wrapped with concrete barriers just feet from the racing surface. In modern racing, this would be seen as some sort of oddity, but through the past decades of motorsport this was the norm. Drivers did express concern for this during the race weekend, but organizers only moved the wall in the *Tamburello* corner back a few extra feet.

Firstly, we must take a look at the track design characteristics. Today, chicanes would be put in place to slow racing cars down around such “high speed tracks”. Chicanes are additions to the track surface that makes a driver slow considerably in a high speed section to make a turn or two before continuing on at full speed. These are used in areas where speeds can be dangerously high. If the FIA, Formula One’s sanctioning body, implemented these, the accident could have been prevented all together. Senna would have had to slow the car to close to 100kph, reducing his crash speed by over half. This alone could have saved his life because the hard impact would have been a slight brush with the wall. With this chicane, which was put in place after the accident, would also allow more run off room for the car to slow down. With more room Grand Prix organizers could put gravel traps into place. These traps would prevent a car from skidding off track and into a solid concrete wall.

Gravel traps are responsible in the racing world, for slowing racing cars down drastically. With the low ground clearances of the cars, they will simply dig themselves into the gravel. If Senna went off course at 220 kph today, a standard size gravel trap would slow his car by half the normal speed. This again would lead to a light brush with the wall. That wall also played a major part in the death of Ayrton Senna. If the wall was set back from the race track it would allow for this proper gravel trap. A combination of the chicane and gravel trap would nearly stop the incident from occurring. The issue here is the speed of the incident. Less speed means less impact, so a crash of this magnitude would not be such a disaster. It begs the question why had this not been thought of prior to the accident. Other tracks implemented these techniques and it has been seen how well they have worked. See Figure 1 for a diagram of the crash with and without a chicane. The blue states the alternate track layout, which Imola did switch to after the Senna accident. Accordingly, most of the track layout did change; the race track had similar turns to the *Tamburello* corner. This made the overall track much safer and set a precedent for all future tracks that were designed.

**Red Line: Actual Crash line, old track layout**

**Blue Line: Alternate Crash line, new track layout**

**Figure 1**

Lastly wall design may have prevented such a disastrous crash. If the track has implemented some sort of tire wall system, Senna’s helmet may not have been impacted. The impact with the wall threw suspension pieces at his head, penetrating his helmet in multiple places. If a tire wall were to be put in place, it would have absorbed enough impact that these pieces would not have entered the cockpit. The weight of the tires would have contributed to this. Because they move and are not rigid like a concrete wall, the tires could have captured the suspension pieces before they were able to fly into the cockpit. Perhaps being a better alternative, would be to use the SAFER barrier. This barrier is made of steel and foam and helps absorb and reduce energy in an impact. If this was to be installed the force of the crash would not be as strong, and would thus limit the amount of flying suspension parts that led to Senna’s death. The SAFER barrier would also reduce the likelihood of Senna being struck in the head by a flying tire. The tire wall and SAFER barrier could reduce the impact energy, which caused the tire to enter the cockpit of Senna’s car and strike him in the head.

If the track layout was designed in a more modern manner, Senna’s accident could have been avoided. He would have crashed off into a gravel trap and not touched any wall, or a very light brush with the wall. On the old track layout, he slammed into the wall at over 220 kph which helped with the trajectory of his suspension pieces enter his cockpit. An alternate crash layout could have saved Ayrton Senna’s life. As the diagram shows, the crash would have simply been an off track experience for Senna, and not a deadly crash. If track organizers implemented proper tire walls and SAFER barriers the force of the accident would not have affected the car and driver with so much energy. The pieces of the car would not have taken such a brunt of impact and throw suspension pieces or launch a tire into the cockpit. If tracks operated in this same way from the beginning, and give appropriate room for gravel traps, chicanes, and SAFER barriers, fewer drivers would have been killed or severely injured in accidents.

Helmet Design

 The construction of Ayrton Senna’s helmet played into his tragic death. If we take a look at the design and make up of helmets today compared to those in the past, it becomes clear how major this factor is. Without the current makeup of the helmet, Felipe Massa would not have survived his scary incident at the Hungaroring in 2009. He was struck in the helmet by a spring that had fallen off the back of a car. While it did keep him sidelined from the rest of the year’s races, he was still alive. The same cannot be said for Senna, who unfortunately, had his helmet penetrated by flying debris from his car.

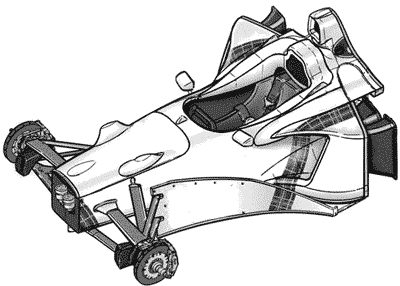
**Senna’s 1994 Figure 2 Vettel’s 2011**

In Figure 2, we see that the construction of the 2011 helmet is much more shaped then that of the 1994 helmet Senna used. This helps dissipate the impacts if the helmet is struck with a foreign object. In the case of Senna’s helmet if an object strikes it, it has nothing to absorb that impact. The padding inside the helmet, and the rigid exterior of it will break if hit hard enough. In Senna’s case this is what led to one of his brain injuries. The helmet of 2011 also weighs significantly less at just over 1250 grams. This low weight keeps the motion of the head very similar to that of a helmetless head, helps a driver from having a whiplash effect in case of a collision. In the older helmets, they were heavy and not very strong. While they did offer some protection, it was minimal at best and leaves possibility for a fatal injury. The outside of these modern helmets is made from a fiber-coated carbon fiber, wrapped around strong Kevlar® padding. This helps absorb impacts that Senna’s helmet did not.

Visors are also a key component of what actually killed Senna. In the past, helmet visors were constructed of a very thin plastic, only made so drivers can see clearly out of them and block flying dust or oils from contacting a racer’s eyes. Most modern visors are made of a special clear polycarbonate plastic, which offers not only excellent vision, but also resistance to flames. The visor also contains a strong Zylon strips across the top of the visor. This increases strength significantly, something that Senna could have used. This strip increases rigidity in the visor, and also gives less visor space for an object to impact. Senna’s helmet did not have this strong plastic resin, and only offered some semi sturdy plastic. In fact, this was the key component that saved Felipe Massa from any significant injuries. The spring struck him in the visor, and it did its job well. The helmet and visor designs if modernized could have helped Senna survive his crash. He was struck in the head through his helmet.

With the modern helmet change, Senna’s head would not have been impacted with suspension pieces. A stronger helmet would have prevented material from breaking his helmet, and suspension pieces from hitting his head. The lighter helmet design would prevent the tire that impacted his head from rocking against the back of his seat, and lead to excessive internal bleeding. A stronger visor would have prevented his face from being impacted with metal pieces that would find their way into his brain. This is because of the violent impact Senna’s head took against the seat and between his helmet.

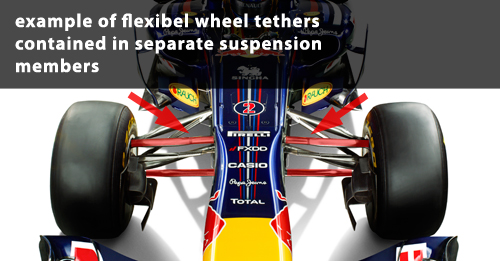
Car Design

The last important structure that could have been useful to prevent Senna’s death is the monocoque, a French term for single-cell. A current Formula One monocoque is constructed with layers of carbon fiber that are increasingly wrapped around one another. These fibers make it very tough and rigid. Incorporated with the carbon fiber, the same Zylon material that is used on the helmet visors reinforces the monocoque. These materials also add an energy absorbing component to it. It makes impacts less on a driver and more on the car, because it absorbs what would normally run though a driver’s body. Senna could have survived if this same idea was used today. The monocoque holds sturdy so that objects cannot enter from 3 sides of it. The only dangerous spot is on the top, but it is necessary to have that for other areas of safety. For example, if there was a canopy system in place, a driver that rolls the car could be trapped inside of it until track marshals got to his or her aid.

**Modern Monocoque**

**Figure 3**

One of the major roles that lead to Senna’s death was the initial impact for a tire that found its way into the cockpit. With a modern tether system in place, which uses strong rope to hold a tire and suspension pieces on a car, Senna could have avoided that impact. The system is simple enough to work with, but had not been thought of at the time of Senna’s accident. The monocoque itself, can withhold enormous impact. It has a safety cell, which holds out all liquid and foreign objects from entering the cockpit, where the driver sits. If used in Senna’s accident it could have prevented the suspension pieces from penetrating into his helmet. He would, in a modern car, be situated in such a way that it would be almost impossible to be penetrated by any of these means. The car itself is shaped around this. Once Senna struck the wall, the suspensions pieces that impacted his helmet penetrated a part of his car body. At the time, the car did not have as much protection for the driver in this area. The cars were designed more for aerodynamics then safety. In recent years, however, the safety is designed first, then the aerodynamics. Each monocoque has a safety cell that keeps out all liquids, oils, and gases that could be involved in running a car. This safety cell can thus help keep dangerous metal pieces from entering the cockpit. Senna could have survived his accident if this same thing held true in 1994.

As part of the car design, modern cars have a tether attached to each tire. This would cause, in case of an accident, tires to be restrained from flying off and striking not only a driver, but also an attendant of a race. In Senna’s case this greatly affected the outcome. Incomplete In his accident, the right front tire, upon impact with the wall, flew off of this car. Unfortunately, it struck him in his head. This caused, including other factors discussed above, his head to violently slam into the back of his seat several times. The impending brain injury could have killed him, let alone repetitive with the other strikes from the suspension pieces in his head and face. If the tire had been tethered in place, as it is in cars today, Senna would not have been struck with the tire. This could have let to him surviving. Included in the safety cell, this together would prevent the dangerous flying objects from hitting Senna’s head.

**Figure 4**

Conclusions

After reviewing all evidence, the initial hypothesis that Senna could have survived with modern motorsport safety measures holds true. Firstly, if track design had been different, the failure in his car would not have led to such a terrible accident. If a chicane would have been in place that he would already be slowing for it. This would have caused him to simply spin off course, instead of contacting a concrete barrier. Had this barrier been a tire wall or SAFER barrier, it would have been more probable that the impact would not have done as much damage as to throw materials of the car into the cockpit of the car and strike Senna in the head. Secondly, a modern helmet design could have saved his life as well. Today’s helmets were built with extra safety in mind. Their construction holds that they can withstand impacts from different materials. Had Senna been wearing a modern helmet at the time of his impact, the lighter design would not have helped his head violently beat the back of the seat. Also the sturdier material would have prevented objects from entering both his visor and main helmet. The car design is a third key factor. Had the modern monocoque been in place objects would not have entered into the cockpit, or safety cell, of Senna’s car. This would have helped Senna by not allowing suspension pieces to enter his head area. If tethering of tires were used in 1994, Senna would not have been struck with his right front tire. With the combination of all three of these issues, it can be concluded that Senna would have survived with a modern car had the same problems with his car occurred. Based on those results motorsport teams and organizations need to keep moving forward with safety procedures. Unfortunately, for safety to advance in racing a tragedy needs to occur. If the race teams and organizations keep moving forward with safety, deaths do not need to occur.